

AVAILABILITY OF N AS A FACTOR AFFECTING THE BIOCHEMICAL STABILITY OF LIGNIN AND PYROGENIC ORGANIC MATTER IN SOILS

Heike KNICKER^{*} and José Maria DE LA ROSA, Francisco J GONZÁLEZ-VILA

IRNAS-CSIC, Avda. Reina Mercedes, 10, 41012 Sevilla, Spain

**) Corresponding author: knicker@irnase.csic.es*

As a consequence of global climate warming extended dry and hot periods are predicted, which favor vegetation fires and the production of charcoal. Introduced into the soil, the latter is considered as highly recalcitrant and to increase the soil C sink. On the other hand, recent laboratory experiments indicated that under optimized laboratory conditions, plant-derived pyrogenic organic matter (PyOM) can exhibit very short residence times < 100 years (Hilscher *et al.*, 2009; Knicker *et al.*, 2013). Possibly, comparable to the degradation of lignite coals (Fakoussa and Hofrichter, 1999; Rumpel *et al.*, 2006), lignin degraders are responsible for PyOM decomposition. Considering further that lignin degradation is affected by N availability, the presence of this nutrient is likely to play an important role for the biochemical stability of PyOM.

In the present study, we evaluated this hypothesis by means of laboratory degradation experiments in which soil material (Histic Humaquept) was mixed with N-poor charcoal produced from wood and with organosolv lignin derived from industrial paper production. The mixtures were subjected to microbial degradation at 28°C in a Respicond IV Apparatus for 10 weeks with and without addition of mineral N-fertilizer. The experimental setup was supplemented by soils amended with N-rich PyOM from grass (de la Rosa and Knicker, 2011) material and ammoxidized lignin (N-lignin) (De la Rosa *et al.*, 2013). The CO₂ production was determined on an hourly base by changing electrical conductivity of a KOH solution (Knicker *et al.*, 2013). The degradation rate constants and the mean residence times (MRT) were calculated using a double exponential decay model applicable to identify pools with fast and slow turnover rates. Alterations of the chemical composition of SOM during degradation were studied by solid-state ¹³C and ¹⁵N NMR spectroscopy.

First results indicated that without N amendment, lignin addition altered only slightly the degradation rate of the slow soil organic matter (SOM) pool (MRT: 10 years). Additional fertilization with KNO₃, resulted in a small increase of MRT. For the soils mixed with N-poor charcoal, a clear augmentation of MRT due to N-addition was observed. Compared to the control, application of N-lignin resulted in faster SOM degradation. Possibly, the restricted access to N immobilized within heterocyclic structures of the N-lignin augmented the

decomposition of the carbon backbone, yielding in a release of the nutrient. Analysis of the degradation process by solid-state ^{15}N NMR spectroscopy confirmed a fast use of this mobilized N for biomass production. Comparable low stability was observed for heterocyclic N structures of N-rich grass PyOM (de la Rosa and Knicker, 2011). Mixed with soil, no major alterations of the respiration rates due to PyOM addition was evidenced, indicating comparable degradation rates of SOM and grass-derived chars.

Our results provide some insights into the interrelationship between the C and N cycles in soils. Addition of N together with N-poor aromatic C sources to soils can decrease CO_2 production. On the other hand, aromatic structures containing heterocyclic N did not increase the C-sequestration potential of the used soil. Although it is commonly assumed that heteraromatic N has higher biochemical recalcitrance than peptide-like compounds, we observed an efficient use of the former for biomass production. Thus, even if N-heteroaromatic structures are formed during humification or introduced with charred residues, our findings indicate that their resistance towards biochemical transformation may not be high enough to increase the C sequestration potential of soils.

REFERENCES

- de la Rosa, J.M., Knicker, H., 2011. Bioavailability of N released from N-rich pyrogenic organic matter: An incubation study. *Soil Biology and Biochemistry*, 43, 2368-2373.
- de la Rosa, J.M., Liebner, F., Pour, G., Knicker, H., 2013. Partitioning of N in growing plants, microbial biomass and soil organic matter after amendment of N-ammonoxidized lignins. *Soil Biology and Biochemistry*, 60, 125-133.
- Fakoussa, R.M., Hofrichter, M., 1999. Biotechnology and microbiology of coal degradation. *Applied Microbiology and Biotechnology*, 52, 25-40.
- Hilscher, A., Heister, K., Siewert, C., Knicker, H., 2009. Mineralisation and structural changes during the initial phase of microbial degradation of pyrogenic plant residues in soil. *Organic Geochemistry*, 40, 332-342.
- Knicker, H., González-Vila, F.J., González-Vázquez, R., 2013. Biodegradability of organic matter in fire-affected mineral soils of Southern Spain. *Soil Biology and Biochemistry*, 56, 31-39.
- Rumpel, C., Alexis, M., Chabbi, A., V., C., Rasse, D.P., Valentin, C., Mariotti, A., 2006. Black carbon contribution to soil organic matter composition in tropical sloping land under slash and burn agriculture. *Geoderma*, 130, 34-45.